UNIVERSITAT JAUME I
Facultat de Ciències Jurídiques i Econòmiques · FCJE

CREATIVITY AND INNOVATION IN BUSINESS

CASE STUDY: PAMESA CERAMICA S.L.U

FINAL DISSERTATION

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1. INTRODUCTION

Nowadays, globalisation means that the evolution of companies is taking place in a competitive environment, turning product innovation into a crucial element for their survival, requiring more innovative tools to differentiate themselves from their competitors.

Innovation and creativity have almost always been linked to an exclusively industrial and technological context. However, this can also be based on the detection of a new business line or on the ability of companies to maintain the highest possible market share. These competitive advantages range from elevated levels of investment and basic research to the smallest changes in the design or presentation of an existing product, as well as manufacturing and market support.

These advantages are necessary for our ceramic sector, as we will speak about in this paper. To this end, our research objective is to analyse the behaviour of innovation and creativity in the products of the company Pamesacerámica, located in the province of Castellón. This sector carries out 95% of its activities inCastellón.

In this process we will talk about the inkjet decoration, the virtual interpretations and the personalized designs that the company PamesaCerámica uses for its products as they will help us to understand the importance of the innovation in quality and design that this entity uses.We also focus on the different machines that Pamesa uses to make these advances.

Finally, once we have commented on the advances of the modern technologies used by this company we will also comment on the benefits they bring to the products, the importance of this technology in the company, the differences we can find in the way of production before the advances and the problems that these new innovations can cause.

2. THEORETICAL FRAMEWORK

In order to deepen our understanding of innovation and creativity within companies, we need to understand some of the concepts and relationships they have with each other. To this end, we will begin by developing the definitions, concepts and types of innovation and creativity that exist.

2.1 CREATIVITY

Creativity is the ability to generate innovative ideas or concepts, or new associations between known ideas and concepts, that usually produce solutions to everyday problems. It is a fundamental element that must be present in all types of work. We can apply this definition to the entrepreneurial world, where creativity is the starting point for business innovation. In this section we will delve into the concept of creativity, the factors that influence and affect creativity and its types, and the relationship they have with innovation and business.

2.1.1 CONCEPT

Creativity in enterprises is a key aspect, especially when major changes are taking place and greater competitiveness is required. It is necessary to know how to adapt, but much more important is to adapt with this advantage to adults, in a more flexible and innovative way. To do this we focus on the author Ditkoff.

According to Ditkoff, "creative people are self-motivated, take risks, see hidden connections, investigate new possibilities, are not afraid of other people's perceptions, focus on problems and new challenges, are more perceptive, are more disheartened, are more willing to learn. These are some of the behaviours of creative people that, if you look closely, clearly benefit businesses". (Ditkoff, s.f.)

If you are looking for specific objectives in the company, this can bring innovative ideas to help you reach this objective in a better way, even to exceed existing expectations. It allows us to go beyond what we expect, to better analyze things and to create interesting initiatives for the improvement of the company.

It must not only depend on senior management, it is important to be able to promote it among the workers, encourage them and give them the opportunity to be creative and contribute as much as possible to the company. In order to do this, the company must create a good working environment, promote creativity as a value of the company, inform and allow suggestions to be offered, recognize efforts in this area and, in short, everything that helps to promote it among workers.

In summary, creativity responds to a company's solutions when it needs to react to changes in its means of action. Creativity is based on finding the relationship between things, the problems that a company has and its assets, to solve these problems together.

2.1.2 TYPES OF CREATIVITY

2.1.2.1 INDIVIDUAL CREATIVITY

"Creativity is not taught or learned in books, but through the daily and reflective practice of all forms of expression coupled with a transforming and transgressive imagination, which makes the human being a critic and transformer of his environment." (Diez, s.f.)

Individual creativity is the basis of any kind of change we can imagine in the world, but today a series of teams of people have developed to generate ideas in order to take advantage of individual imagination.

2.1.2.2 GROUP CREATIVITY

One of the advantages of group creativity is the possibility of uniting different minds working for the same reason. The productivity of the teams' union is greater when common sense is required, i.e., to obtain previous experience or certain skills to achieve the objective.

By bringing together a group of hardworking, dynamic people who are willing to learn from each other, individual talents are better utilized, and in many cases various opinions are needed to respond. discuss or modify ideas.

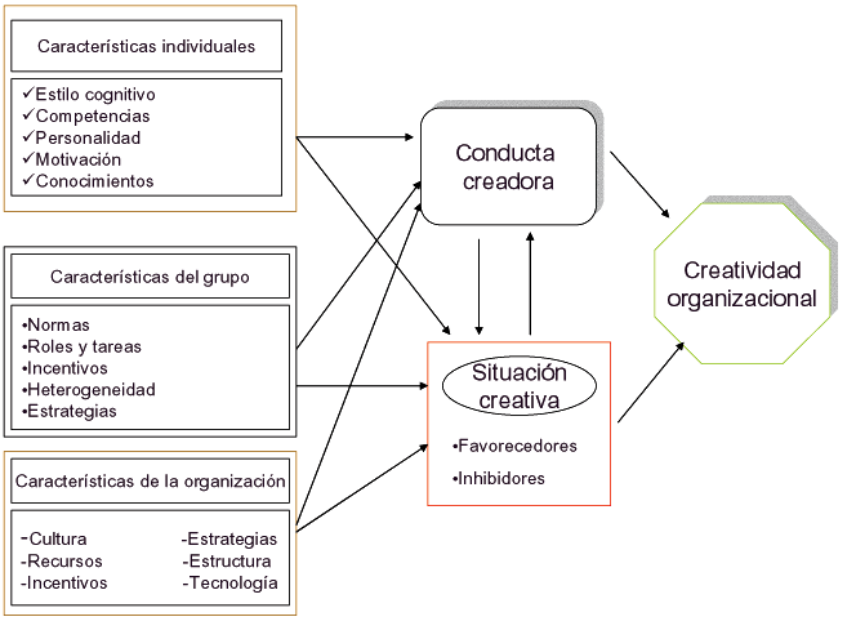
2.1.2.3 ORGANIZATIONAL CREATIVITY

In order to stimulate organizational creativity, our company follows a series of suggestions such as, for example:

- Stimulate new ideas, where managers from top management to frontline supervisors must clearly assume that they are open to new ideas and approaches.
- To develop the recruitment to change, the members of the organization must know that the changes will make them gain benefits for themselves and the company.
- A greater integration, obtaining a permissive and creative climate in order to offer the opportunity to integrate with other members.
- To tolerate mistakes, that is to say, even if many ideas do not lead to any solution, questions should be listened to and clarified, and even new ideas should be offered.
- Define clear objectives and grant freedom to achieve them.

- Offer recognition, that is, motivate the staff.

GRAPHIC 1: TYPES OF CREATIVITY



Source: diverse types of creativity in companies

2.2 INNOVATION

2.2.1 THE CONCEPT OF INNOVATION

Innovation is defined as "the creation and modification of a product and its introduction to the market". More technically, innovation is defined as "the transformation of an idea into a saleable, new or improved product, into an operational process in industry and commerce or into a new method of social service".(Innovación, s.f.)

For its part, the COTEC Foundation defines innovation as "the art of turning ideas and knowledge into new or improved products, processes or services that the market values".

In conclusion, innovation can be considered as the commercial application of an idea in such a way that new or improved products, processes or services are created, allowing the generation of business profits. As vital as innovation, it is dissemination and commercialization that make the idea generated useful.

2.2.2 IMPORTANCE OF INNOVATION

It is important that in the midst of a time of crisis such as the one we are livingin, companies must have enough efficient skills to be able to use creativity and innovation against their competitors.

One study cites that creative entrepreneurs are 81 percent more likely than others to value innovation as a crucial capability of the company.

Here we see again how innovation is once again a determining factor for companies.

Innovation has become the most important engine of transformation and growth for companies. It is key to the growth of companies and to the evolution of new products.

Today, the business world is much more competitive than it has been up to now. These changes have brought us innovations such as, for example, in the ceramic sector, personified tiles in which you can observe through programs that present virtual reality, that is, how the tiles would look in the place that the client would like to place them.

Companies have realized that not only can they make a living by reducing costs and increasing efficiency, they need growth and hence the importance of innovation throughout the value chain, not only at the product level, but also at the level of the market they are facing and adapting the company to the current situation. For one innovation to be competitive with another it should follow a few characteristics.

- Must be perceived by customers
- Clearly, the company must bear the cost of the investment in this new innovation.
- It must be sustainable over time, protecting it if necessary.

2.2.3. TYPES OF INNOVATIONS

Next, we will classify innovation into distinct categories. The Oslo Manual is based on the previous classification of J. Schumpeter, which divided innovations into five types: introduction of new products, new production methods, opening of new markets, development of new sources of raw material supply and the creation of new market structures in a sector. This classification has changed slightly over time due to advances and modern technologies.

Based on the previous Oslo manual, there are four diverse types of innovations: those related to products or services, those related to processes, market innovations

and organizational innovations. The first two (product and process) are the most related to technological innovation, as defined above.

- Product or service innovation is the introduction of a new or improved good or service into a market. Including in the improvements the modification of their technical characteristics, of the components, new materials or giving them a different use. Such innovations can enable companies to position themselves more favourably in the market and become market leaders.

- Process innovation is the introduction of a new or improved production or distribution process. Including changes in the techniques, materials or computer systems used. This type of innovation is basically carried out to reduce the unit costs of manufacturing or marketing, which can generate a significant cost advantage over the competition, to increase productivity and to improve process quality.

- Marketing innovation is the application of a novel marketing technique that modifies the design, packaging, market positioning, advertising or price of an asset. This type of innovation is fundamentally carried out to improve the company's competitiveness and increase sales by improving consumer satisfaction, opening the company to new markets or otherwise positioning itself in the market.

- Organizational innovation is the application of a new organizational system in the company, a radical change in the organization of the workplace or the internationalization of the company. This type of innovation is fundamentally carried out to optimise the results of a company by reducing management or supply costs, or to increase the level of well-being in the workplace by increasing productivity.

In addition to this classification, innovations can also be measured depending on the degree of novelty on the market.

- Incremental innovations are those that improve existing goods and services on the market. So, they happen quite often.

- Radical innovations, however, are usually the result of R&D&I activities carried out in companies or public research centres.

2.2.4 INNOVATIVE COMPANIES

Faced with an increasingly changing world and the shaking of markets, innovation is becoming an essential tool to ensure the survival of companies, whether large or small. because an innovative company is one that can systematically introduce this research and development, that is, it is adapting changes that occur in the market, making it more competitive for companies in the same market.

One of the main characteristics of the innovation process that gets companies started is the management that goes with it. Managing the complexity and uncertainty of change. To this end, the figure of the innovative entrepreneur should be present at all times, who is the promoter of the evolutions that are carried out in the company where he or she assumes the risks that the change may have.

When an entrepreneur accepts these changes, he or she is taking risks in order to achieve competitive advantages.

Different theories carried out by J. Schumpeter, define the innovative entrepreneur as the promoter of the economy, due to the importance it has for promoting innovations in the company.

2.2.5 INNOVATIONS AND STRATEGIES FOLLOWED

When companies decide to implement an innovation in search of a greater return on capital, they must consider factors such as the cost of making the innovation and the expected benefit. Therefore, there are two aspects that determine the profitability of this investment in innovation. In the first place, the rarity of the innovation, that is, the ease with which it can be copied or the exclusivity of the new acquisition. Finally, it is also important to see the availability of resources that we have in the company to face the new acquisition, since you can obtain the innovation by acquiring through your own funds, with credits, or combinations of both, since future steps will have to be taken, emphasizing that when obtaining a credit there are always risks.

After having commented on these two aspects of innovation, we can develop a form of measurement where we find four possible degrees of efficiency in the implementation of an innovation.

GRAPHIC 2: STRATEGY FOR THE DEGREES OF EFFICIENCY

STRATEGY FOR THE DEGREES OF EFFICIENCY

	AVAILABILITY OF RESOURCES		
		Fewresources	Many available resources
	Plagiarism	Partnering	Accelerate
	Hardly imitable	Lock	

Source:Adaptedfrom QUALICER 2008

- Alliance: when the resources of the companies are insufficient, and the innovations are very easy to imitate, these do not provide profitability in the long term, therefore, a serious strategy that the company which has few resources is associated with other companies to be able to take advantage of all the available resources together.

- Increase the speed: when you have a lot of resources you want to accelerate the production or creative process in order to obtain differentiated products against the competition in a shorter period of time than the competition can imitate it, therefore, when the competition is able to imitate the product, the company has managed to develop a new and more differentiated to the previous one.

- Blocking: on the one hand, the company may have sufficient resources, or, on the other hand, the innovation introduced in the company is complex enough to be easily copied, for which the company must protect these innovations from competition.

2.2.6 RELATIONSHIP BETWEEN CREATIVITY AND INNOVATION

So far, we have developed separate concepts, but these concepts that we have tested are part of a process that companies have used to become more competitive in relation to their competitors. Due to the need to adapt to changes affecting the environment in which the company operates. These changes are the triggers of this process.

Creativity can be constituted as an aid for the solution of problems within an organization or a work team. It provides new ways to analyse the nature of a problem and to generate a wide variety of options for its solution. On the contrary, the concept of "Innovation" represents in itself a creative solution, that is to say, a change that is made with the purpose of solving a problem or improving a situation.

3. CERAMICS SECTOR

The Spanish ceramic tile manufacturing industry is one of the most dynamic and innovative in Spain and, within the world ceramic sector, is positioning itself as a leader in terms of technological development, design and quality of service.

Of the global turnover, around 80% corresponds to exports and the rest of the sales are destined for the domestic market. The ceramic sector is the third largest industry contributing to Spain's trade balance, with total sales in 2016 reaching 3,316 million euros. The experience and knowledge as differential values have favoured the presence of our products in nearly 190 countries.

One of the main characteristics of the Spanish tile sector is the high geographical concentration of the industry in the province of Castellón, especially in the area bounded to the north by Alcora and Borriol, to the west by Onda, to the south by Nules and to the east by Castellón de la Plana. Approximately 94% of the national production comes from this province, where 80% of the companies in the sector are located.(1)

GRAPHIC 3: THE CERAMIC SECTOR AND ITS SALES

El sector cerámico en 2016

Producción	Exportación
492	2.570
Empleo	**Ventas totales**
15.000	3.316

Producción y ventas del sector

	2012	2013	2014	2015	2016
Producción	404	420	425	440	492
Ventas mercado nacional	575	557	574	643	746
Exportación	2082	2240	2328	2452	2570
Ventas totales	2656	2793	2902	3095	3316

Source: ASCER 2017

3.1. COMPETITIVE INDUSTRY

3.1.1. EXPORT

The Spanish ceramic industry is one of the most competitive on the international scene, thanks to its quality and its constant commitment to innovation and the development of new products and applications. Some data where you can appreciate the high degree of competitiveness of the Spanish ceramic industry are:

- First exporter in volume in the EU.
- Second largest exporter in volume worldwide.
- Despite the fact that the Spanish ceramic network is made up almost entirely of SMEs and family businesses, Spain has been the second largest producer in the world for years and currently - the latest figures available date from 2015 - is in fourth place with 3.6% of world production.
- The average annual turnover of the sector in the last decade has been close to 3,500 million euros.
- In terms of exports and imports, the average coverage rate of the sector's trade balance over the last decade has exceeded 2,300%, making this figure the national leader among the main industrial sectors.

3.1.2 NATIONAL MARKET

The Spanish ceramic industry is the undisputed leader in the Spanish market, thanks to its characteristics in R&D, its quality and its development of new products and applications, well ahead of the vast majority of its competitors.

Currently, the sector's sales are distributed approximately 65-70% for foreign trade and the remaining 30-35% remain in the domestic market. Taking into account that the sales of the Spanish ceramic industry are made to more than 180 countries, this last percentage represents an important figure.

Less than 10% of the ceramics sold in Spain comes from abroad, which shows that the domestic market, which is the largest per capita consumption of ceramic material in the world, prefers Spanish ceramics for its quality and wide range of products compared to products from other countries.

The volume of sales of Spanish ceramics in the domestic market over the last decade has been over 1,000 million euros per year.

3.1.3. THE FUTURE OF TILE LINKED TO INNOVATION

The industry is increasingly penetrating with great force in the economic fabric of Castellón and especially in the tile cluster. One of the most recognized firms, both nationally and internationally, is PamesaCerámica, which has been a pioneer in recent decades in the implementation of modern technologies.

Pamesa's technical director, Juan Luis López, reports that "the main companies in the ceramic sector already have a fairly elevated level of process automation". "In fact, when we show the factories to people outside the industry, the first thing that surprises them is the high productivity and that most of the people in the plant are specialized in process control, where manuals have already been discarded.

Over time, the current concept of tile manufacturing will be transformed, but it should not be forgotten that in the ceramic process a series of physicochemical reactions take place, mainly in the firing process (1,200ºC), which make this type of work difficult and, therefore, its total effectiveness.Juan Luis López argued.

The future of the tile will be incorporated with the maximum possible innovations. An example that we can argue is that the trend in the sector is to make bigger and bigger pieces, and in the case of Pamesa, innovations have been installed in the production and logistics process to manage them.

There are some very interesting projects that are underway, such as the one led by machine and glaze manufacturers to apply glazes and engobes using a technique, i.e. digital inkjet printing, which will allow significant savings to be made in applying glazes and engobes to the pieces.

Currently there are other lines of work by machine manufacturers that aim to improve the productivity of factories and optimize the connectivity of different machines that make up the same production line with the same software. According to Pamesa, each machine now informs the ERP of its operation and performance and through the ERP they manage the data for global decision making during the production process.

When it comes to breaking down the technological advances that have already been implemented in Pamesa's facilities, the factories have a large number of machines that have robotic components such as the Kerajet machines, which allow for the immediate removal of the tiles in printed form, or the LGV machines that allow internal logistics to be carried out without the need for people, there are robots in the packing and packing line, and there are also radiofrequency installations in all the warehouses.

The Pamesa Group has also been a pioneer in the progressive implementation of automatic warehouses in recent decades and today we have two in the

Almassorafactory and some semi-automatic warehouses in the rest of our factories. In addition to this, we have 40 digital decoration units installed, state-of-the-art presses and ovens and a logistic organization that makes us pioneers in the distribution of our products.

Pamesa has advanced software that integrates and allows online control from the purchase and receipt of raw materials to the delivery of the finished product to its customers. We can say that we are in tune with the concept of industry, although the sector, due to its characteristics, will need time to adapt to it.

Another of the main characteristics of the Pamesa Group is its agility in the face of change, and this is possible due to its working culture, in which there is a permanent desire for improvement, from the management to the last operator and the means that allow us to undertake them.

Pamesa's innovative vocation has also been reflected in advances in marketing. Its aim is to be at the forefront in all fields and at Cevisama to present a new technology at world level; tiles with digital printing thanks to inkjet technology. This innovation, exhibited at the tile stand at trade fairs, allows for the design and creation of environments in augmented reality.

3.2. THE COMPANY: PAMESA CERAMICA S.L

3.2.1. HISTORY OF THE COMPANY

PamesaCerámica is the parent company of the Pamesa Group, dedicated to the design, manufacture and marketing of ceramic products. It was founded in 1972 by Francisco RoigBallester and Trinidad Alfonso Mochilí, as an industry for the manufacture of ceramic flooring, being one of the few companies of its time that covered the entire production process up to direct sales.

PICTURE 1: PamesaCeramica in 1972
Source: History - 1972 Pamesa is born as an industry for the manufacture of ceramic flooring

In 1987 the first compact porcelain stoneware plant was started and in 1981 it became the first factory in Spain to implement the production of porcelain stoneware, which made Pamesa the leading company in Spain in the manufacture of this type of product. For this reason, it received the Alfa de Oro at the Cevisama International Fair, one of the most important ceramic products fairs in the world.

In 1989, the first computerized warehouse with more than 16,500 pallet-sized storage locations was set up. That same year, Pamesa received the Valencia Innovation Award from the GeneralitatValenciana.

In 1993, Pamesa was committed to sustainable development by incorporating environmental protection equipment into its facilities, with an environmental management system, a waste water recovery plant and three cogeneration turbines to produce electricity and the reuse of gases.

In 1997 PAMESA created its subsidiary in Brazil, PAMESA DO BRASIL, dedicated to the polishing of porcelain stoneware.

Shortly afterwards, he decided to invest heavily in the creativity of the designer Agatha Ruiz de la Prada, giving fruit to avant-garde collections within the world of ceramic design. At this time, the company acquired greater prestige due to the innovation of its trends.

In 1999 he received the Award of Excellence for the best porcelain stoneware product.

In 2010, the use of accumulators in air-conditioning systems began, and it received the Alfa de Oro for its efforts in new fields of application for ceramics.

Due to the international presence of the company, in 2013 it obtained the Export Award granted by the Chamber of Commerce of Castellón.

2014 the company wants to move towards a sustainable business model and focused on meeting the needs and expectations of its customers, betting on a long-term relationship of trust with them, offering them reliable products and services that enable them to open new marketing lines.

Today the company is run by the children and relatives of Don Francisco RoigBallester.

3.2.2 CORPORATE VALUES

PamesaCerámica focuses on corporate values focused on design and innovation, with the aim of anticipating the needs and expectations of its customers, offering them the highest quality products in accordance with the ISO 9001:2008 standard. They also have a commitment to the client, being this the business center of the company, oriented to have a long-term relationship of trust.

Teamwork is the spirit of all the activities of this company, taking on the challenges together and professionally. They work with transparency, integrating a commitment to social and environmental economic progress into their performance.

3.2.3 SHAREHOLDING STRUCTURE

From the birth of Pamesa in 1972 to the present day, Fernando Roig has managed to create an empire that has become the main producer of tiles in Spain.

The growth of the company began in 2008, due to the crisis, which has been a great business opportunity for the entrepreneur through multiple mergers and acquisitions that have made Grupo PamesaEmpresarial currently have twelve companies and more than twice as many employees as it had initially.

One of the main keys to success has been to achieve control of the entire ceramic production process, from obtaining the raw material to marketing the finished product, which has led to greater profitability due to independence from suppliers or a network of marketing companies that would potentially increase the cost price of the product.

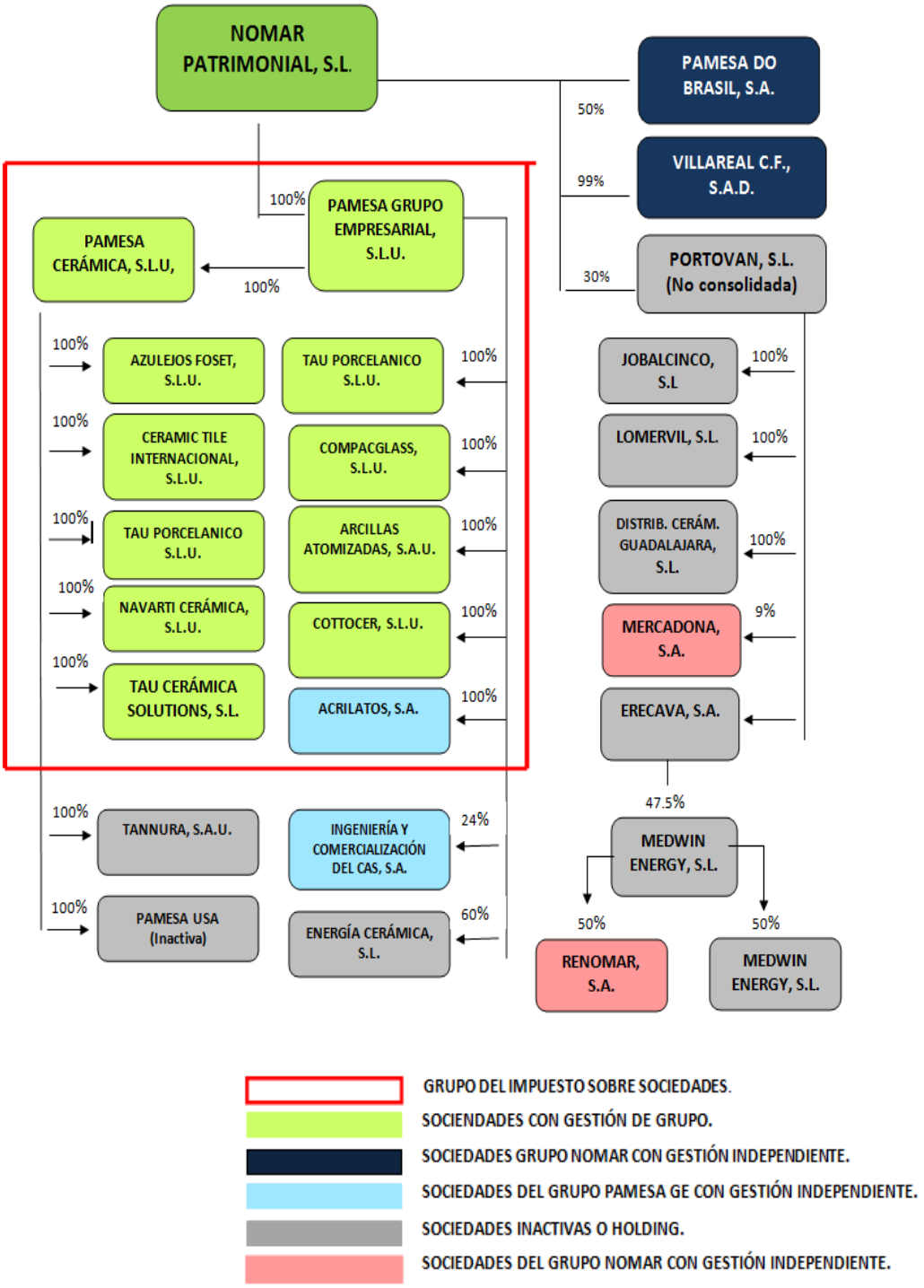
Fernando Roig's company has two raw material companies: Atomized Clays and Compacglass dedicated to the production of atomized earth and energy. PamesaCerámica, Cottocer and TAU Cerámica, in charge of the manufacture of tiles and in the commercialisation part, PamesaCerámica, Geológica Tile and Azulejos Foset, which have their own commercialisation network.

It also has an auxiliary materials company for the ceramic sector, Acrylates, which supplies fluidizers to the industry in the ceramic production process.

In addition, abroad, Pamesa do Brasil, whose activity is not included in Pamesa Grupo Empresarial, and internationally, Pamesa has a trading company in the United States, Pamesa USA, which is currently inactive.

"Pamesa Grupo Empresarial has been able to become a true tile empire thanks to its commitment to investment from the outset as the cornerstone of its economic policy".(Ribés, 2016)

GRAPHIC 4: PAMESA GROUP ORGANIZATION CHART



Source: own creation

3.2.4 CORPORATIVE IMAGE

Pamesa is an industrial group dedicated to the design, manufacture, distribution and marketing of ceramic products with the aim of satisfying the needs of its customers, ensuring an excellent quality, design and price ratio.

Its mission is to consolidate its leadership in the national and international market for wall and floor tiles, stoneware and ceramic floor tiles, developing values for all the company's stakeholders such as:

- Design and innovation: anticipate needs and expectations, offering top quality products (Alfa de Oro for its efforts in new fields of application for ceramics)
- Commitment to the customer: to build lasting relationships of trust with customers by offering them different terms and methods of payment to both national and international customers.
- Ethics and sustainability: working transparently and committing to economic, social and environmental progress (ISO-9001 certified by Lloyd's Register Quality Assurance).
- Teamwork: PamesaCerámica is always concerned about its workers and offers many options for helping them, such as social funds, school aid, insurance policies, and even commits itself to workers who may suffer from alcoholism by taking care of certain detoxification treatments.

The company, in collaboration with the Roig Alfonso Foundation of the Valencian Community, promotes the social and labour integration of people with intellectual disabilities by providing them with the possibility of having a Special Employment Centre, with the aim of reinforcing their training and the social and labour integration of these people. This social commitment has given more than 1,000 intellectually disabled people the opportunity to develop by creating around 1,650 new murals that will be exhibited in stores like Mercadona during 2018.

It is also committed to sport as another form of commitment to society, officially sponsoring Villareal C.F., world triathlon champion Javier Gómez Noya and Valencia Basketball, with whom it shares the values of teamwork, effort and improvement.

PICTURE 2: VillarealC.FPamesaCeramia S L
Source: Pamesa Ceramic Villarreal CF: equipment 2014- 2015

3.2.5 HATCHING OF INVESTMENTS IN THE TILE

The extensions that the factories are having increase by almost 7 percent the total area dedicated to the production of tiles in Castellón in just three years and the costs of machinery have increased in the plants in the province.

The tile industry and related sectors are undergoing a process of reform to be able to adapt to the new market requirements, which has led to a large part of the sector to strengthen its investment in both infrastructure and machinery, reaching the point of having increased, a little more than three years, by almost 7% the area dedicated to production as we have said before. The industry has also increased its expenditure on machinery by more than three percent and has seen an increase in investment in design, marketing and sales in units yet to be qualified.

One third of the companies located in the province of Castellón have carried out expansions of their production and storage plants since 2014, with the aim of increasing the square meters of manufacturing and driven by the need to meet the strong foreign demand preferably.

On the other hand, machinery has been provided, especially with regard to new furnaces or the important investments being made in the field of production in leading companies such as Pamesa, Porcelanosa, Argenta, among some twenty firms.

In addition to the growing interest in investing in new manufacturing lines, there are also actions aimed at digitizing production processes and adapting structures to industry 4.0, something that will mark the immediate future of the sector, as pointed out by the group of ceramic technicians, who will take these new intelligent factories to the

international congress. To date, at least half a dozen companies already have partially or fully digitized processes in the province.

Companies in Castellón continue to be at the forefront of R&D&I investment. If the tile factories have kept their investment intact for years, the manufacture of semi-finished raw materials (atomised, frits, glazes and ceramic pigments) and third fire parts have seen their contributions increase in this respect in order to gain market share. As far as innovation is concerned, the advances made through the Institute of Ceramic Technique (ITC) are noteworthy.

Another aspect that has been highlighted by tile manufacturers has been investment in ceramic machinery, which is beginning to rebound, driven by the activation of demand and the revitalization of the domestic and foreign markets, low interest rates and the contributions and aid that are beginning to arrive, although still at a trickle.

4. CERAMIC TILE MANUFACTURING PROCESS

The manufacturing process of ceramic tiles takes place in a series of successive stages, which can be summarised as follows:

- Preparation of raw materials.
- Raw forming and drying of the piece
- Firing or firing, with or without enamelling
- Additional treatments
- Sorting and packing

Depending on whether the product to be manufactured is glazed or not, or whether it is manufactured by a single, double or third firing process, the glazing will or will not be carried out in a given process, or the sequence of the glazing and firing stages will be modified in the appropriate way. (Graphic 5.)

GRAPHIC 5: DIAGRAM OF THE MANUFACTURING PROCESSES CONSIDERED.

Source: tile making department

Preparation of raw materials. The ceramic process begins with the selection of the raw materials that must form part of the composition of the paste, which are mainly clays, feldspars, sands, carbonates and caolines.

In the traditional ceramic industry, raw materials are usually used as they are extracted from the mine or quarry or after minimal treatment. Its natural origin requires, in most cases, a previous homogenization that ensures the continuity of its characteristics.

Conformation of the pieces.

Dry pressing. The predominant part forming process is dry pressing (5-7% humidity), using hydraulic presses. This part forming process operates by the action of a mechanical compression of the paste in the mould and represents one of the most economical processes in the manufacture of ceramic products with regular geometry.

The pressing system is based on hydraulic presses that carry out the movement of the piston against the die by means of oil compression and have a series of characteristics such as: high compaction force, high productivity, ease of regulation and constancy in the established pressing cycle time.

The presses have developed a lot in the last few years and are equipped with very sophisticated automatisms that are easily adjustable and very versatile.

Extrusion. Basically, the extrusion forming process consists of passing a column of paste, in a plastic state, through a matrix that forms a piece of constant section.

The equipment used consists of three main parts: the drive system, the die and the cutter. The most common propulsion system is the propeller system.

Drying of formed parts. Once formed, the ceramic piece is subjected to a drying stage in order to reduce the moisture content of the pieces after forming to a sufficiently low level (0.2-0.5 %), so that the firing and glazing phases can be properly carried out.

In the dryers normally used in the ceramic industry, heat is transmitted mainly by convection, from hot gases to the surface of the piece, with the radiation mechanism slightly involved from these gases and from the dryer walls to the surface.

Therefore, during the drying of ceramic pieces, a simultaneous and consecutive displacement of water through the wet solid and through the gas takes place. The air used must be dry and hot enough, as it is used not only to remove water from the solid but also to supply the energy in the form of heat, which is needed for the water to evaporate.

The pieces are currently dried in vertical or horizontal dryers. After the parts have been formed, they are introduced into the dryer, where they come into contact with hot gases countercurrent. These hot gases are supplied by an air-natural gas burner or by hot gases from the furnace's cooling chimney. The main heat transmission mechanism between the air and the parts is convection.

In vertical dryers, the pieces are placed in metal planes, forming different units commonly known as'baskets' between several planes. The basket assembly moves vertically inside the dryer, with the basket-piece assembly coming into contact with the hot gases. Normally the temperature in this type of dryer is less than 200ºC and the drying cycles are usually between 35 and 50 minutes.

The horizontal dryers are designed as single-layer roller kilns. The workpieces are inserted in various planes inside the dryer and moved horizontally inside the dryer above the rollers. The hot air, which comes into contact with the parts countercurrent, is supplied by burners. located on the sides of the oven. The maximum temperature in this type of installation is usually higher than in the case of vertical dryers (around 350ºC) and the drying cycles are shorter, between 15 and 25 minutes.

In general, horizontal dryers have a lower consumption than vertical dryers, due to the better layout of the parts inside the dryer and the lower thermal mass. The emission resulting from the drying operation is a flow of gases at a temperature of around 110ºC and with a very low concentration of suspended particles carried from the surface of the parts by this flow.

Cooking or firing, with or without glaze.

In the case of unglazed products, firing is carried out after the drying stage. Likewise, in the case of glazed products manufactured by double firing, the first firing is carried out after the raw pieces have dried.

Enameled. Glazing consists of the application by different methods of one or more layers of glaze with a total thickness of between 75-500 microns, which covers the surface of the piece. This treatment is carried out to give the cooked product a series of technical and aesthetic properties, such as: impermeability, ease of cleaning, shine, colour, surface texture and chemical and mechanical resistance.

The nature of the resulting layer is essentially vitreous, although it often includes crystalline elements in its structure.

Glazes and frits. Glazing, like ceramic paste, is composed of a series of inorganic raw materials. It contains silica as a fundamental component (glass builder), as well as other elements that act as fluxes (alkaline, alkaline earth, boron, zinc, etc.), as opacifiers (zirconium, titanium, etc.), as dyes (iron, chromium, cobalt, manganese, etc.).

Depending on the type of product, its firing temperature, and the effects and properties to be achieved in the finished product, a wide variety of glazes are formulated.

In other ceramic processes (artistic porcelain, sanitary ware), only and exclusively crystalline raw materials, natural or synthetic, are used in the formulation of glazes, which provide the necessary oxides. On the other hand, in the process of ceramic floor and wall tiles, raw materials of a vitreous nature (frits) have been used, prepared from the same crystalline materials previously subjected to a high temperature heat treatment.

Frits: Nature, advantages, composition and manufacture. Frits are vitreous compounds, insoluble in water, obtained by melting at high temperatures (1500ºC) and then rapidly cooling predetermined mixtures of raw materials. The vast majority of glazes used in the industrial manufacture of ceramic floor and wall tiles have a greater or lesser proportion of frit in their composition, being able to treat in some cases a single frit or a mixture of different types of frits.

The use of frits has the following advantages over the use of unfritted raw materials for a given chemical composition:

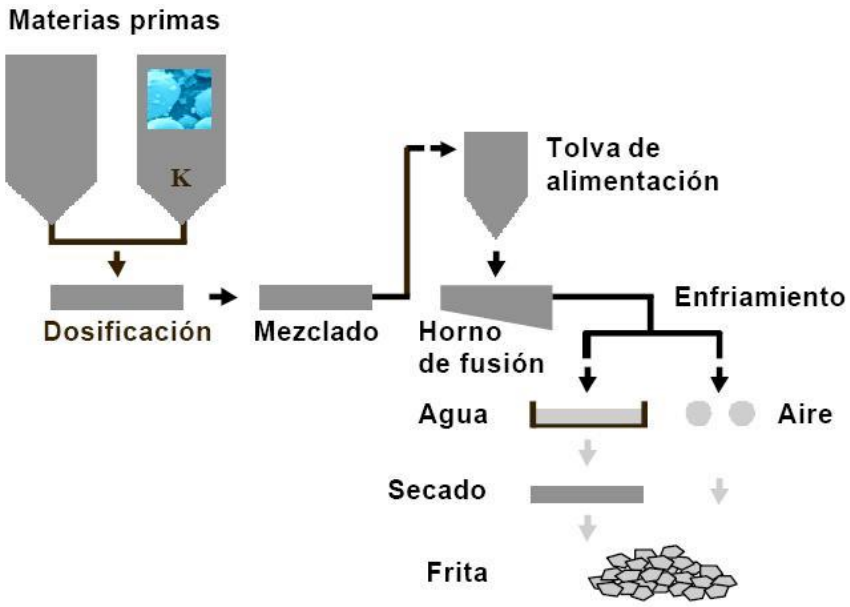
Insolubilization of some chemical elements.

Decrease in toxicity, the vitreous material obtained, due to its size and structure, has a lower tendency to the formation of environmental dust than the raw materials from which it comes, thus reducing the danger associated with its toxicity.

Extension of the working temperature range of the enamel, due to the fact that they do not have defined melting points.

The manufacturing process of frits, commonly called fritting, aims to obtain a vitreous material insoluble in water, by melting and subsequent cooling of mixtures of varied materials.

GRAPHIC 6: FRIT PROCESS



Source: tile making department

The process begins with a dosage of the raw materials, previously selected and controlled, in the established proportion. The different raw materials are conveyed pneumatically to a mixer (Graphic 6).

There is a great variety of ceramic frits, which differ in their chemical composition and in the physical characteristics related to it. As previously explained, components that are soluble or toxic are always supplied in fritted form to reduce their solubility considerably; this is the case with lead, boron, alkalis and certain other minority elements. The rest of the components can be used in fried form or as crystalline raw material, depending on the desired effect.

Frits can be classified according to many different criteria: their chemical composition (lead, boracic, etc.), their physical characteristics (opaque, transparent, etc.), their melting range (fluxes, hard), etc. At present, a series of frits have been developed for certain production processes, which encompass several of the characteristics sought, and which make the classification of ceramic frits even more difficult.

The mixture of raw materials is fed into a feed hopper, from where it enters the kiln, where it is fried. The furnace is fed through a worm screw, the speed of which controls the mass flow of material fed into the furnace. The residence time of the material inside the furnace is defined by the melting speed of the raw materials and the fluidity of the melted material.

The furnace is equipped with natural gas burners, which are used as oxidizing air or oxygen. These systems allow to reach temperatures between 1400-1600ºC, necessary to carry out this type of process.

The combustion gases are passed through a heat exchanger before being expelled to the outside through the chimney in order to recover energy for preheating the combustion air.

The fritting process can be carried out continuously, using continuous furnaces with water or air cooling of the melt and discontinuous, with rotary furnaces and water cooling.

The continuous furnaces have an inclined base in order to facilitate the decrease of the melted mass. At the outlet there is an overflow and a burner that acts directly on the viscous liquid into which the frit has been converted at the outlet, avoiding its sudden cooling in contact with the air and facilitating the continuous emptying of the oven.

Cooling can be done:

With water. The molten material falls directly on water, which causes it to cool down immediately. At the same time, due to thermal shock, the glass is broken into small, irregularly shaped fragments. These are usually extracted from the water by means of a worm screw and then transported to a dryer to remove the moisture from the previous treatment.

With air. In this case, the melt is passed through two cylinders, cooled inside by air, obtaining a very fragile laminated solid, which breaks easily into small flakes.

The intermittent process is carried out in the event that you wish to manufacture frits with lower demand. In this case, the melting process is carried out in a rotary kiln and normally the frit is cooled by water, which is the only difference from the continuous process.

The rotary kiln consists of a steel cylinder lined inside with refractory material and equipped with a handling system that allows the melt to be homogenized. At one end of the furnace is a burner that directs the flame into the furnace.

In both the continuous and intermittent processes, the fumes from melting contain gaseous compounds from combustion, gases from the volatilisation of the raw materials fed and particles carried by the combustion gases at the kiln outlet. It is

important to note that the composition of these particles is similar to that of the frit that is being produced at any given time.

Glazes: Preparation and application. Decoration. The process of preparing the glazes usually consists of subjecting the frit and additives to a grinding phase, in an alumina ball mill, until a predetermined rejection is obtained. The conditions of the aqueous suspension are then adjusted, the characteristics of which depend on the method of application to be used.

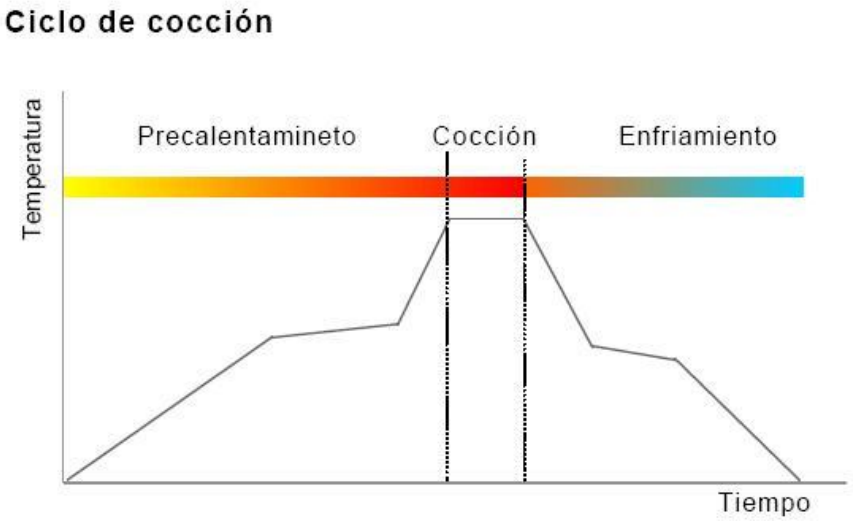
The glazing of ceramic pieces is carried out continuously and the most common application methods in the manufacture of these ceramic products are: curtain, spray, dry or decorations.

Silk-screen printing is the technique most commonly used for decorating ceramic tiles, due to its ease of application in glazing lines. This technique is used in single firing, double firing and third firing, and consists of achieving a specific design that is reproduced by application of one or more superimposed screens (stretched fabrics of a given mesh size). These screens have the whole of their surface closed by a hardening product, leaving only the drawing to be reproduced free to pass through. When an element that exerts pressure (scraper) passes over the screen, the screen printing paste is forced to pass through it, leaving the impression on the piece.

Cooking of the pieces. The firing of ceramic products is one of the most important stages of the manufacturing process, since a large part of the characteristics of the ceramic product depend on it: mechanical resistance, dimensional stability, resistance to chemical agents, ease of cleaning, fire resistance, etc.

The fundamental variables to be considered in the firing stage are the thermal cycle (temperature-time, Figure 7) and the furnace atmosphere, which must be adapted to each composition and manufacturing technology, depending on the ceramic product to be obtained.

GRAPHIC 7: FIRING CYCLE



Source: tile making department

The firing operation consists of subjecting the pieces to a thermal cycle, during which a series of reactions take place in the piece that cause changes in its microstructure and give them the desired final properties.

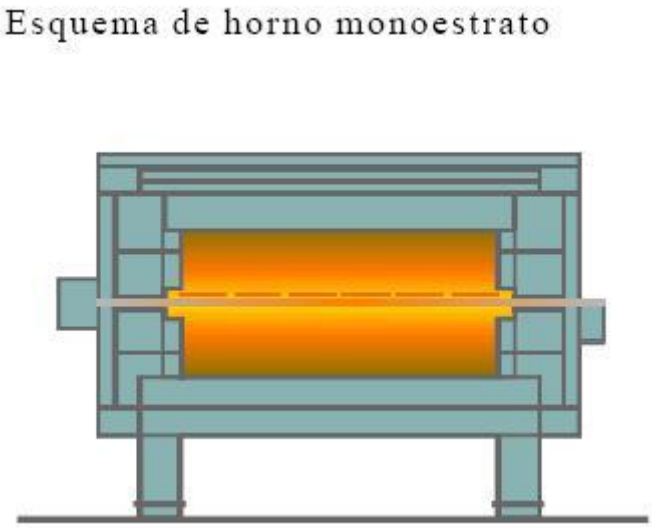
Single, single and double firing. Ceramic materials may undergo one, two or more firings. The unglazed tiles are fired once only; in the case of glazed tiles, they can be fired after the glaze has been applied to the raw tiles (single-fired process), or they can be fired for the first time to obtain the support, to which the glaze is applied and then fired again (double-fired process). Some decorated materials are fired a third time at a lower temperature.

Sometimes there may be additional drying after the glazing stage. This is carried out immediately before the material is introduced into the oven, in order to reduce the moisture content of the pieces to levels sufficiently low for the firing stage to develop properly.

Quick cooking. The rapid firing of ceramic tiles, which is currently predominant, is currently carried out in single-layer roller kilns, which have made it possible to reduce the duration of firing cycles to less than 40 minutes, due to the improvement in the heat transmission coefficients of the pieces and their uniformity and flexibility.

In single-layer ovens, the pieces move over the rollers and the heat required for cooking is supplied by natural gas-air burners located on the walls of the oven. The main heat transmission mechanisms present during this process are convection and radiation. (Figure 8).

GRAPHIC 8: SINGLE-LAYER FURNACE SCHEME



Source: tile making department

As these are non-muffled furnaces, the contact of the gases with the product is direct, which improves the heat transport coefficients, reducing the duration of the firing cycle, reducing energy consumption and increasing the flexibility of these furnaces with respect to those previously used for this process.

The hot gases resulting from the cooking operation are emitted into the atmosphere by two emission sources. On the one hand, the fumes from the preheating and baking area are emitted to the outside by a chimney at the entrance to the kiln and the fumes from the cooling area are emitted by a chimney at the exit of the kiln.

The fumes from the preheating and cooking process are mainly composed of substances from combustion and gaseous pollutants from the decomposition of raw materials and suspended dust particles. As for the fumes in the cooling stage, they are hot air and may contain dust particles.

Additional treatments. In some cases, particularly porcelain stoneware tiles, a surface polishing operation is carried out on the fired pieces to obtain homogenous, glossy, unglazed tiles.

Classification and packaging. Finally, with the classification and packaging stage, the manufacturing process of the ceramic product is completed. The classification is carried out by means of automatic systems with mechanical equipment and superficial vision of the pieces. The result is a product that is tested for dimensional consistency, surface appearance and mechanical and chemical characteristics.

4.1 INDUSTRY TRENDS

At the moment, the Spanish ceramic industry is considered as much in design, quality of the materials used and innovation as one of the most important at international level, competing at the same level as Italy as the leader in this sector.

Although in recent years it has been manufacturing technologies that have set the trends in the ceramic tile sector with reproductions with materials such as marble, stone, wood, cement, etc., thanks to new digital decoration technologies and the reduction in the cost of materials, the possibility of ceramic tile formats oriented towards neutral materials has increased considerably. Stones, marbles and cements will continue to be of particular importance, joined by noble materials such as pure metals, steels and terrazzo, claimed by designers and architects such as John Pawson, who has used these materials for the new London Design Museum.

In addition, the small format is becoming increasingly important in simple and traditional designs that seek to be updated for a renewed vision of ceramics.

These are the most important trends in the ceramic market:

- Metallic Look. Aged gold and pink, brass and copper are the finishes that stand out at the latest design fairs.
- Stracciatella Passion. The terrazzo of the 60s and 70s is re-emerging, while in the rest of Europe it has been growing little by little in recent years. Spain is somewhat reticent about this material because it is associated with low quality construction, but this trend is advancing in all European countries.
- Touch Surface. Ceramics generates body and volume together with three-dimensional effects, thanks to the technological advances implemented in the sector that demonstrate the progress towards ceramics with greater decorative importance. The basic resources will be geometries, micro-relief, volumes and surface textures.
- Back to the origin. In both public and residential interior design, recent years have been marked by neutral ceramics, in which minimalist and industrial styles have been predominant.
- New Memphis. This trend proposes designs full of color and a great spectacularity, highlights the decoration that uses simple geometries, so circles, squares or triangles make up collections that are characterized by their versatility in the application, as they allow the user to play with the compositions adapting to the space.

5. METHODOLOGY: INTRODUCTION TO INKJET TECHNOLOGY

5.1 INTRODUCTIONTO INJET TECHNOLOGY

5.1.1 CONCEPT AND CHARACTERISTICS

INKJET digital printing is the inkjet technology applied to the finishing of ceramic tiles. With this new innovation, the Spanish ceramic sector has made significant progress in the research of this technology. Great possibilities for the decoration of the claddings that adorn the houses in an almost present future.

One of the characteristics of this technology is that the ceramic inks are printed directly on the tile, which allows different colors to be mixed to create unique finishes that will dress the floors or walls of the environment to be coated.

Another feature is the creation of digital printing with cold ink.

The use of inorganic inks does not require printing at high temperatures so if pigmentation does not suffer attenuation. In this technique we can find pros and cons. The use of this type of technology causes or produces 100% ceramic products, since its resistance and durability will not be the same as that of a vitrified ceramic piece.

INLJET technology has been introduced in the ceramic sector to go one step further in the finishing of floors and walls. Some chromatic possibilities to personalize the ceramic tiles.

5.2 PAMESA MAKES THE MOST OF THE ADVANTAGES OF DIGITAL TECHNOLOGY

The PamesaCerámica catalogue stands out for combining the highest aesthetic features with unbeatable technical characteristics and a wide variety of finishes and formats.

An article in the Mediterranean newspaper talks about Cevisama 2016 in which Pamesa presents important novelties in red body and revitalized versions of its porcelain tiles.

PamesaCerámica presents at the 2016 edition of Cevisama a wide range of products, the results of which are the result of its commitment to innovation, quality and design, shaped by maintaining the path set in previous years as the introduction of new digital technologies in the manufacture of ceramic products, which are the result of the implementation in all the enamelling and decoration lines of the new digital printing equipment.

In red paste, the series in 20x60 Aztec, Maya and Win-Winter formats stand out; and in 31x60 Faenza and Forli. These combinations of the different textures of these series achieve the attention for the mixture of primitive elements with the most current

trends. There are two series that form part of the master lines of one of the most stylish and current collections of red pasta in 25x85 format. On the one hand, Vertou has arrived to set the trend with indigo and mauve colors, inspired by the tulip fields of Holland, accompanied by the elegant white, sand and marengo of neutral softness. On the other hand, following the path of this format, Madras was born, which takes up again the spirit of high decoration. This is the series that will cover the wall of your home creating a luxurious ambience, inspired by the classic onyx marble, that comes back to life with the sharp elegance of the contemporary key.

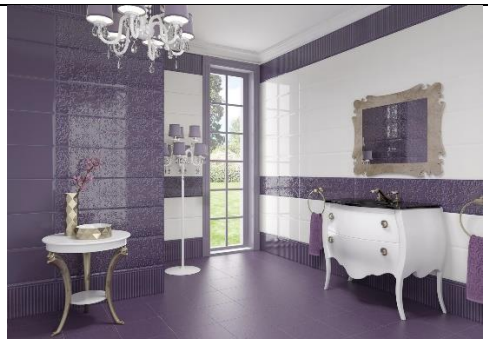
The company is also pleased to give more life to its porcelain fan with Thule and Reef.

Another of PamesaCeramica's great bets for this edition of Cevisama is Puzzle. The series, made in 25x40, presents an innovative concept and comes credited for its enormous commercial success and endorsed by the signature of the brilliant designer Agatha Ruiz de la Prada. This new collection is defined by its different design, so special and fun. Puzzle ceramics is designed for passionate and restless people who work with the same commitment and passion as they celebrate the great events. Puzzle has not left anyone indifferent, as it floods with its strength and magnetism and provides all the daily energy and vitality needed to keep up with the frenetic pace of life in today's society.

Puzzle has arrived to set the trend, offering a variety of colours to choose from: yellow, orange, carmine, turquoise, pistachio and white, which can also be combined with the classic 25x50 already in the catalogue. It is complemented with pieces in relief where the forms of its funny and recognized designs stand out to the touch.

As we have well named several types of PamesaCerámica product lines we will now show you some images with each of them:

TYPES OF PRODUCT LINES	PHOTO
MAYA TILE	

AZTECA TILE	
WIN -WINTER TILE	
FAENZA TILE	
FORLI TILE	
VERTOU TILE	

MADRAS TILE	
THULE TILE	
REEF TILE	
PUZLE TILE	

PIICTURE 3: **types of product lines**
Source: catalogue of PamesaCeramica

6. KERAJET

When we refer to inkjet decoration, i.e. digital decoration, we are talking about KERAjet, which is a revolution in ceramic technology as it saves costs and increases creativity.

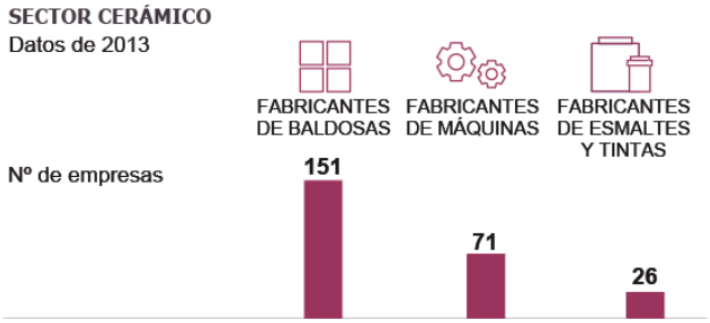
Thanks to the new technologies patented by KERAjet, the ceramics can be decorated directly and without any contact from the staff. It obtains a great

characteristic that is the printing of edges and reliefs that makes the designs acquire naturalness.

Kerajet's technological leap forward has been made with the entire Spanish tile sector, 40 square kilometres located in the province of Castellón, which is home to 95% of the companies in the sector.

The first stone of this industrial cluster was laid in the 19th century, and for decades it has alternated world leadership with Italy until the emergence of China, which sells a product of inferior quality. "Castellón has become the great centre of world development. The machine manufacturers cooperate with the ink and glaze manufacturers and the ceramic manufacturers.

GRAPHIC 9: CERAMICS SECTOR



Empleados	14.500	1.737	3.342
Ventas (en millones)	2.797	341	1.159
Exportación (en millones)	2.240	341	792
Ventas nacional (en millones)	557	162	367
Patronal	ASCER	ASEBEC	ANFECC

Source: ASCER 2013

The companies after the fall that took place in 2008 and 2010 knew how to maintain themselves because despite the high investment involved in the implementation of this new technology they knew that the productive, aesthetic and logistical benefit of the digitalization was so great that within a year the investment was amortized.

The change brought about has been vital in overcoming the crisis. Digitization has made the industry more competitive in cost, performance and design compared to other surface coating industries. Exports have increased to 80 percent of Pamesa's sales.

The two leaders in the ceramic sector are Porcelanosa and Pamesa, two family-run companies established throughout the world. The Porcelanosa Group belongs to the Colonques and Soriano families, has a turnover of almost 260 million euros, 1,000

employees in Castellón and another 4,000 in 150 countries. It is known for its extensive network of stores with its own brand.

Fernando Roig is the owner of Grupo Pamesa, the Spanish leader in the ceramics sector, which shares shares in PamesaBrasil only with a local partner. Its five Spanish factories sold 344 million euros in 2013, 27% more than the previous year, will close 2014 with 390 million euros, and in 2015 they expect to maintain double-digit growth since 2010. "Changing its traditional machinery for digital allowed us to maintain our leadership, investing more than 15 million euros and increasing the weight of exports from 45% to more than 70%", explains Javier Portales, purchasing manager of Grupo Pamesa.

6.1 TYPES OF PRINTING USING PAMESA CERAMICA

6.1.1 CERAMIC PRINTING

PICTURE 4: KERAjet S7 model
Source: information of the manufacturing department of PamesaCeramica

This model is called KERAjet S7 and includes the most advanced technology applied to the digital printing of ceramic pigments such as salts, effects, granules, glazes, inks, etc.

It has a compact and robust design which makes it a perfect machine to be integrated into a production line where in turn consists of advanced electronics and innovative software that makes it the most versatile and complete equipment on the market.

It uses different technologies and typologies of print heads in a synchronized way, allowing for unlimited decoration of glazes, colours and decoration, dry, thus achieving the unique and competitive product that today's market demands.

Basic characteristics:

- New distributed ink control system.
- Up to 12 fluids. Quick ink change.
- Continuous ink recirculation system of our own design.
- Maximum printing stability.
- Colour modules in frames with movements from single to quadruple.
- Control of extraction of modules by frames.
- Automatic purging and cleaning system.
- Heating system and ink cooler with individual temperature control.
- Safety system for automatic detection of maximum height exceeded by each module frame.
- Robust system of movements by air bridge.
- Unique meniscus-differential pressure control system.
- Maximum thickness of pieces to print 46mm, (expandable on request.
- Possibility of printing tests without stopping production.
- Web printing speed: Up to 90m/min (depending on the production process and printing units).
- Vertical Resolution: From 180 to 1200dpi.
- Horizontal Resolution: From 254 to 1016 dpi.
- Inks: Inks, enamels and granules for inkjet decoration (always certified by KERAjet.
- Drop size: From 10 to 200pl.
- Trigger frequency: from 6 to 65 KHz.

PICTURE 5: KERAjet P7 model
Source: information of the manufacturing department of PamesaCeramica

This model is also called KERAjet P7, which is a very advanced technology that allows the application of fingerprints, making it an indispensable equipment for the development of new products.

This machine allows to print quickly and easily and is perfect for the development of parts for both laboratory prototypes and for the manufacture of special products.

You get high productivity and print quality at high resolutions with its versatility of configurations.

Basic characteristics:

- Choice of heads: K4, K6, K8, K9, K11, K12, etc.
- Vertical resolution: 180 to 1200 dpi.
- Horizontal resolution: From 254 to 1200 dpi.
- Inks: Inks, enamels and granules for inkjet decoration.
- Drop size: From 10 to 200pl.
- Network: Ethernet connection 10/100/1000 Base T.
- Electrical requirements: 220V 50-60Hz 16A P=4Kw with shuko connector.
- Connectivity: movement and prayers over ethernet.
- High system productivity.
- High print resolution.
- Maximum positioning accuracy.
- Active ink recirculation system for maximum positioning accuracy.
- Digital decoration up to 12 colours.
- Integrated touch screen.

6.1.2 PRINTING GLASS

PICTURE 6: KERAjet Glass Mosaics
Source: information of the manufacturing department of PamesaCeramica

This machine is called KERAjet Glass Mosaics

Basic characteristics:

- New distributed ink control system.
- Up to 12 fluids. Quick ink change.
- Continuous ink recirculation system of our own design.
- Maximum printing stability.
- Colour modules in frames with movements from single to quadruple.
- Control of extraction of modules by frames.
- Automatic purging and cleaning system.
- Heating system and ink cooler with individual temperature control.
- Safety system for automatic detection of maximum height exceeded by each module frame.
- Robust system of movements by air bridge.
- Unique meniscus-differential pressure control system.
- Maximum thickness of pieces to print 46mm, (expandable on request.
- Possibility of printing tests without stopping production.
- Web printing speed: Up to 90m/min (depending on the production process and printing units).
- Vertical Resolution: From 180 to 1200dpi.
- Horizontal Resolution: From 254 to 1016 dpi.
- Inks: Inks, enamels and granules for inkjet decoration (always certified by KERAjet.
- Drop size: From 10 to 200pl.
- Trigger frequency: from 6 to 65 KHz.

6.1.3.- KERAJET LAUNCHES INTO THE FUTURE

With the experience gained and after presenting the revolutionary'K8' for digital glazing and'K9' for solids application in 2014, KERAjet presents at Cevisama 2017 the complete solution for the ceramic decoration line of the future: digitalised ceramic manufacturing plants from atomised earth to the final palletised product ready for sale.

PICTURE 7: CEVISAMA 2017

Source: BolgPamesaCeramica

This innovative advance towards the factory of the future is possible thanks to the collaboration with Spanish companies, machinery manufacturers and

experts in complementary fields, through the combination of synergies.

It achieves high productivity, which has led to a new concept of a complete plant: high productivity at low cost, complete flexibility in formats and maximum possibilities of combining different types of product in the same line, in a digital way, with a versatile and efficient sorting, packaging and palletising line.

Parallel to Cevisama 2017, KERAjet offers its customers the real possibility of getting to know the so-called'Complete Digital Line' at its Open House, which is held inside its facilities at its headquarters in Almassora.

The'Complete Digital Line' is the sum of four elements:

1. First of all, the pressing area, which allows the digital pre-press decoration, for the realization of technical and standard products by means of a dry decoration machine based on its'K9' heads. This allows the earth to be decorated before pressing for mass decoration. Part formats up to 4 metres in length and widths of up to 600 and 1,200 millimetres can be adapted to the customer's specific requirements.
2. The digital decoration area allows the use of different technologies and types of print heads in a synchronized way for the realization of an unlimited decoration of glazes, colors and dry decoration, concentrating in a space of only 2.5 meters in length the application of up to 12 different applications in each machine, more than 100 applications in just 40 meters.
3. Thirdly, KERAjet Visio, the machine vision quality control system, which allowsunattendedquality control of the product at every stage of production on the different sections of the line.And finally, the packaging area, which includes sorting, packing and palletising, versatile and agile in format changes, personalised and digital packaging, which is decorated in line, allowing a significant reduction in costs.

6.1.3.1.- ADVANTAGES

KERAjet's complete digital line combines in a new production solution a greater differentiation, a substantial improvement in product quality and an increase in competitiveness. This revolution of the company allows a remarkable differentiation of the products obtained and offers, at the same time, the best relation quality and benefits for cost of the whole market.

With its characteristics, it enables the creation of customized products, the highest quality printing available and greater versatility in the range of applications and finishes.

6.1.3.2.- BENEFITS FOR THE COMPANY

"We have opted for inkjet technology, digital printing, which is revolutionising the ceramic industry and is the future. This is how Pamesa's director, Fernando Roig, told it, one of the keys to his group's success.

The triumph of the digital printing technology developed by the ceramic group Pamesa increases its profit by 13% in 2017 to 51 million euros.

In 2017, PamesaCerámica S.L.U. increased its turnover thanks to innovation by 26%, with an investment of 63 million euros.

73% of the company's turnover is exported.

The Castellon-based Pamesa Empresaria group, which is dedicated to the production and sale of ceramic materials, atomised earths, chemical products and the marketing of energies, achieved a turnover of around 584 million euros in 2017, which represents a growth of 26% compared to 464 million euros in 2016.

The turnover of the previous year (2017) of ceramic material exceeded 72 million square meters thanks to the innovation that Pamesa has in creating its products, that is, thanks to the KERAjet printer which allows the creation of a high volume of products compared to the old machines dedicated to the same.

The Group's investment in property, plant and equipment in 2017 amounted to 63 million euros, with the cumulative volume of investment since 2014 amounting to 183 million euros.

This aspect, together with the significant investments planned for the coming years, will enable the PamesaEmpresarial Group to continue growing both in terms of sales and production and to continue generating employment in the coming years.

At the end of 2017, the Group recorded a profit before tax of 51.1 million euros, an increase of 13% compared to the profit before tax in 2016.

This increase in profits has been due not only to the increase in sales mentioned above, but also to the use of economies of scale and improvements in productivity and energy efficiency.

The objectives of the PamesaEmpresarial Group for the 2018 financial year are to consolidate sales levels, with the aim of exceeding 630 million euros in turnover, as well as continuing to grow on the level of results obtained in 2017.

6.2. IMPORTANCE OF TECHNOLOGY

Saving time and materials compared to previous inkjet is a good starting point for understanding the importance of this innovation. But the importance of this technology lies elsewhere.

In addition to the cost, the evolution of the market demands more developed products of higher quality and design to match its price. As a Spanish market, this competes in the market for quality and design. And this technology has allowed us to develop an infinite number of designs that the previous technology could not carry out. The use of different alphanumeric patterns allows you to vary the designs and adjust the colors. It is not surprising that such an innovation is very important for companies.

As we have explained in the birth of this technology, these machines were developed by a Spanish company. KERAJET, located in Castellón, was the pioneer in this technology, making the development the patent for this type of machinery. This information is important for the Spanish market, as Spanish companies have always had to adapt to Italian. This, therefore, is one of the first innovations developed by Spanish companies in the sector.

6.3. DIFFERENCES WITH PREVIOUS TECHNOLOGIES

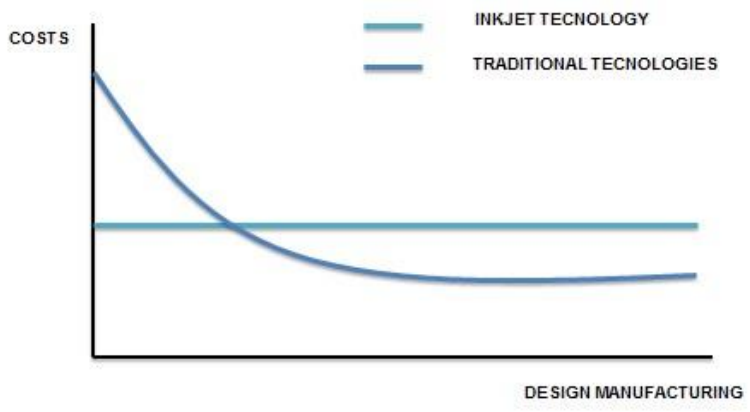
To understand the importance of inkjet technology, as we said, the best way is to compare technologies. At this point we will develop the differences between technologies and sales that this brings about as a result of the previous one.

This technology has led to a breakthrough in the traditional decoration of the sector. According to the experiences of operators, who work with these technologies on a daily basis, the predecessor techniques: screen printing, rotogravure or flexography, screens and rollers needed to transfer the different colors of the design.

To develop these decoration techniques, many elements are required to achieve a design that is only effective for one type of design. This meant a cost of envelopes on engraving templates and rollers, as well as proofs to adjust the design and colors of these templates.

The following chart, as explained in the book "Industrial Inkjet for dummies", shows the costs incurred by the two types of techniques, inkjet and traditional. While inkjet costs are constant, they only need inks. The techniques used so far require a great deal of expense to develop the design.

GRAPHIC 10: COSTS OF VARIOUS TECHNOLOGIES



Source: Adapted from "Industrial Inkjet for dummies"

As we can see from the graph, the costs of various technologies used in the manufacture of a design, the short-term inkjet technology is less expensive due to the lack of use of templates. But in the long run, since the inks and glazes of traditional technologies are so exploited and there are so many companies that manufacture them. In the long run, they are cheaper.

In addition to these represented costs, to produce different designs we had to change templates, and we needed a physical place to store them. This increases costs because workers lost time changing and cleaning templates to produce a new shipment with a different design.

In addition to the excessive costs involved, put in the design possibilities. To represent the final design, the colors are reproduced using the set of small dots of primary colors, representing a single color and a single

unique design in the final composition. For each primary colour a template is required, so the design possibilities are reduced to simple and very expensive frame compositions, due to the cost of each template and work is done to coordinate all the colours, with their corresponding templates, to form the final design.

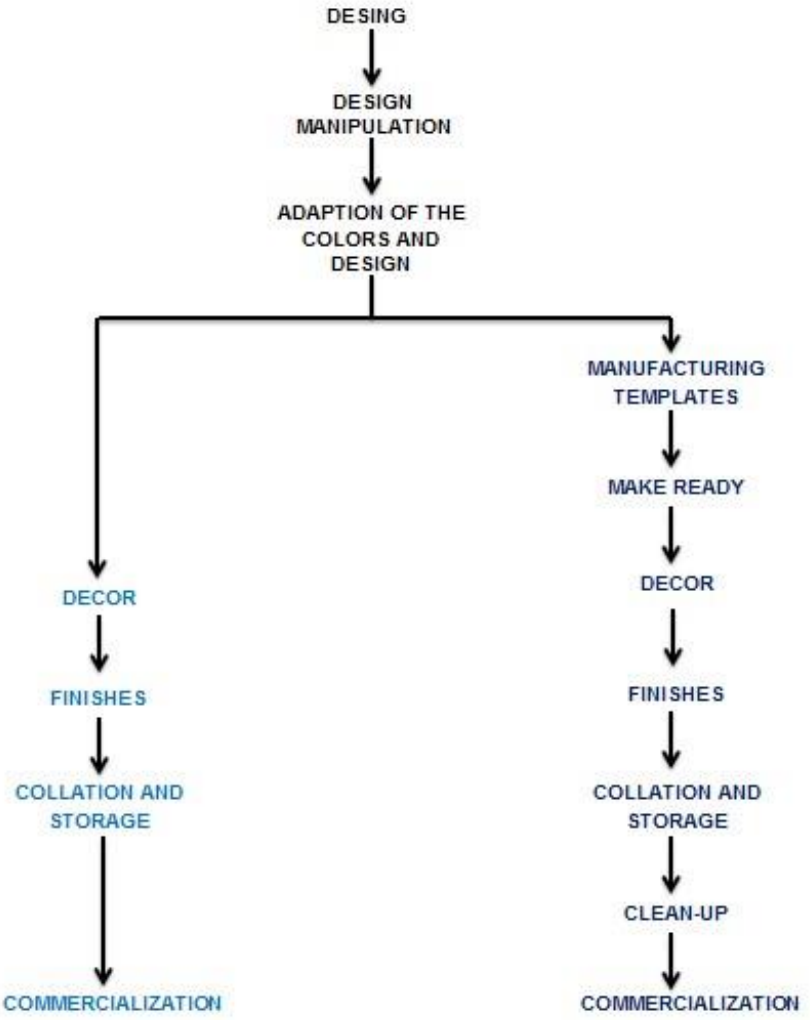
With the evolution of technologies and the emergence of rotogravure and flexographic technologies, it could evolve in this direction, but costs remained the same, because the use of templates remained essential.

Another problem with the use of these techniques is that the suppliers of these machines were the same as the manufacturing templates and rollers, so the company was obliged to buy the templates and rolls from the same manufacturer.

In general, we can represent the procedure of using two technologies in the following graph. The graph below details the main steps in decorating ceramic pieces

in two ways that have proven the traditional and inkjet method. The initial steps are the same, the choice of design, the manipulation of the design to adapt it to the parts and the subsequent manipulation to adapt to the technology to be used. This includes a breakdown of colours and shapes.

GRAPHIC 11: STEPS OF BOTH TECNOLOGIES



Source: Adapted from Industrial Inkjet for dummies

The graph below details the main steps in decorating ceramic pieces in two ways that have proven the traditional and inkjet method.

In short, the market evolution allowed to improve gradually the techniques used in the field, but still, the costs and the complication of the use of these.

6.4.PROBLEMS WITH NEW INNOVATIONS

In addition to all the improvements that are provided to companies, and to the sector in general, can bring problems. Starting with the investment of machines, in the Spanish market most of the companies in the sector are SMEs, and for small companies it is usually more difficult to make large investments, as in this case the installation of inkjet machines. This is an example of why the Spanish market is behind the Italian market.

Another problem with this technology is to take full advantage of the offers, the operators who use them must be aware of the machines they are using. To mitigate this problem, ASCER is developing ceramic decoration courses using Inkjet technology. This is another of the cluster's advantages for companies in the sector.

The disadvantages or problems that the implementation of decorative inkjet technology can be for companies, is the variation of the inks that are used. Due to the constant evolution of the inks, to adapt to the machines, the substitution of the components of these inks is constant, which means changes in the color and the way of use. For the company this translates into constant testing and changes to adjust the designs and colors of these.

7. RESULTS

7.1.- CONCLUSION

During the work, we have described innovation and creativity separately, although they are necessarily correlated, during this point we develop more clearly the relationship between them and what these concepts represent for the business world, and in particular what is the development of the technology we have developed for the sector and for the company.

REATIVITY AND INNOVATION

As the title of the project suggests, creativity is the starting point of this whole project. This interaction between creativity and innovation, graphically explained thanks to the studies developed by Medicon Valley Academy, in the model called'The Bridge', helps us to understand the necessary relationship between the two. Creativity as a starting point, from which ideas will emerge, which will then be developed and put into practice by innovation.

The importance of this point is that, as a whole, the initial phases are determined throughout the process, therefore, these phases will determine the greatest success of the company.

Innovation is one of the most important concepts in the business world at the moment, since innovation is of a kind that, in the process, product, organization and marketing, can make the difference of the company with respect to the competition, which translates into higher profits. Moreover, not only for individual companies but also for the economy of a country is beneficial, a clear example of this is the result of investments in technology made for years by the BRICS countries, which currently exceed the levels of growth in the more developed countries.

As a conclusion we can obtain, that the interrelation of these concepts is necessary, they cannot give you separate concepts.

CERAMIC INDUSTRY

As we have explained, ceramics is a very competitive sector, since the resulting product is not distinguishable between companies, although it is true that depending on the raw materials and production processes the products will be of a higher or lower quality, the products are usually indistinguishable. For any of these types of differentiation, innovation is necessary, either to obtain cheaper products, or to develop products with higher quality and better designs.

The Spanish market, the second and fourth European world, is characterised by a high concentration of the ceramic industry in the Castellón area, made up of the majority of SMEs. These companies, due to their small capital, are not sufficient to develop innovations, so cooperation between companies in the sector leads to the importance of the existence of clusters, specifically in this industry the Spanish Association of Ceramic Tile Manufacturers (ASCER).

Specifically, in the Spanish market, the innovation presented during the project, the implementation of inkjet decoration technology is an important innovation in this sector, for several reasons. It is an innovation developed by a Spanish company, this aspect is important because the Spanish ceramic sector depends technologically on Italy, the power of tile production. The second important aspect for the Spanish tile industry is what it means for the production companies, reducing the cost and saving time in production, together with the possibility of developing better designs, important, bearing in mind that the Spanish market develops its activity focusing on the delivery of good quality and design.

THE COMPANY

PamesaCerámica is the parent company of the Pamesa Group with a vocation for leadership dedicated to the design, manufacture and marketing of ceramic products that satisfies the needs of its customers, ensuring an excellent quality, design and price ratio.

With more than 40 years of experience, the Pamesa Group has a built area of more than 700,000 m² and a turnover of 415,000,000 euros. The company has three intelligent warehouses with 65,000 locations and a production capacity of over 61,000,000,000 m² per year. With a diverse, experienced and committed team of professionals, the Group has 1150 employees.

PamesaCerámica S.L.U. understands innovation as an essential aspect for the development of its activities. Not only the application of innovations that arise in the sector but also the development of their own innovation projects, such as the examples presented during the development project of new products such as the tiles used by the Inkjet decoration technology.

In order to know the level of innovation of the company, they must be classified among the factors in favor and against the implementation of this technology. On the one hand, the possibilities for innovation and the reduction of production costs are a very important aspect to consider. But, on the other hand, being a relatively new technology, the application of inks that are suitable for production and design is not yet successful in adapting at all. In addition to taking full advantage of the performance that these machines can offer us, specific knowledge is required for their management.

In addition to these factors, positive or negative, it depends on the production of the company, since all the models manufactured do not need this technology. Therefore, defining the company as innovative or not, based on the use of this technology, depends on the% of the models manufactured with Inkjet.

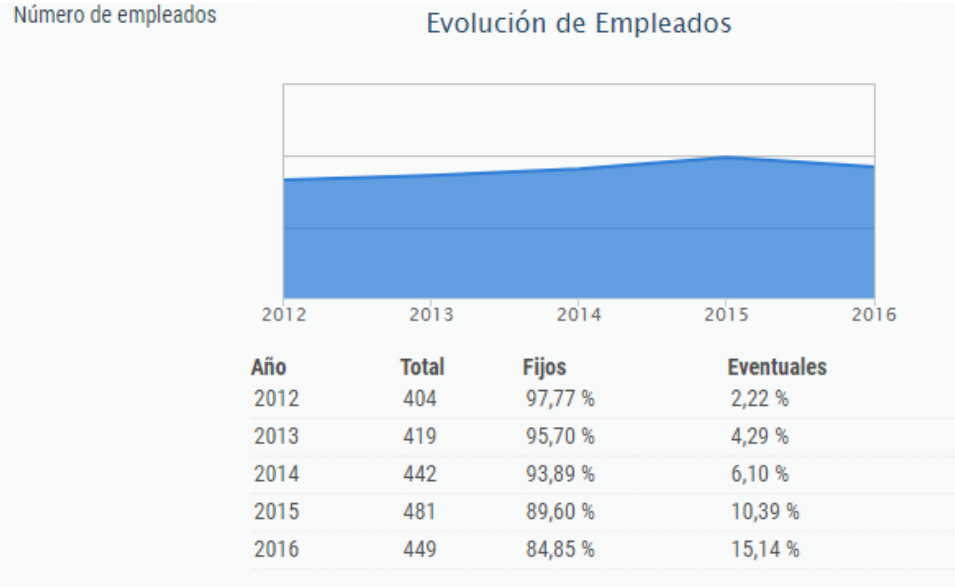
In particular, take into account the company exhibited during the project, both for its location in the Spanish sector and for the ranking that follows: PamesaCerámica S.L.U. had sales of 336,705,000 euros in 2016, for which it obtained the 460th position in the National Ranking of Companies according to sales, improving by 54 positions with respect to 2015.

In the Castellon Ranking according to sales, the company PamesaCeramicaSl in 2016 has achieved position 1, improving by 1 position over 2015.

PamesaCeramicaSl has obtained in 2016 position 1 in the Ranking of Companies in the Ceramic Tile Manufacturing Sector according to sales, maintaining the same position with respect to 2015.(2)

PamesaCeramicaSl in 2016 has registered assets of € 258,717,000 and sales of € 336,705,000.

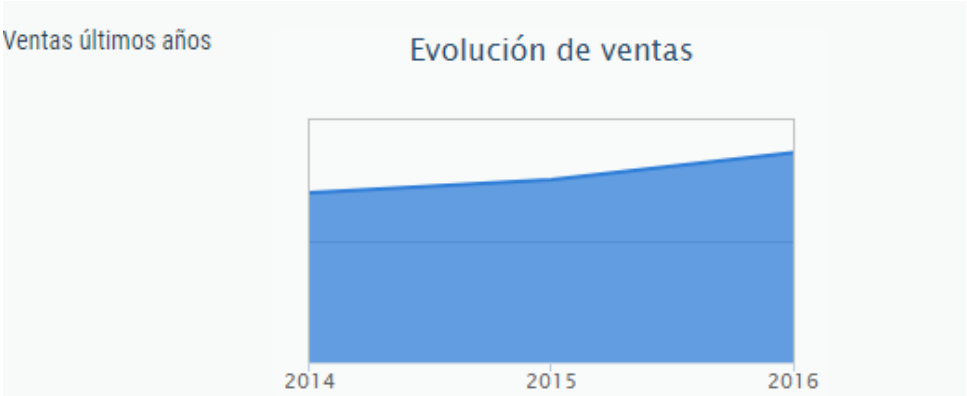
GRAPHIC 12: EMPLOYEE DEVELOPMENT



Año	Total	Fijos	Eventuales
2012	404	97,77 %	2,22 %
2013	419	95,70 %	4,29 %
2014	442	93,89 %	6,10 %
2015	481	89,60 %	10,39 %
2016	449	84,85 %	15,14 %

Source: commercial data of PamesaCeramica

GRAPHIC 13: SALES DEVELOPMENT



Año	Valor	Variación
2014	272.395.000 €	
2015	293.004.000 €	7,57 %
2016	336.705.000 €	14,91 %

Source: commercial data of PamesaCeramica

GRAPHIC 14: RANKING

Ranking Nacional	Posición 460 ↑
Ranking Provincial	Posición 1 de Castellon ↑
Ranking Sectorial	Posición 1 de Fabricación de azulejos y baldosas de cerámica →

Source: commercial data of PamesaCeramica

Below, we show you the evolution of PamesaCeramicaSl's positions between 2015 and 2016 for each of the rankings according to sales.

GRAPHIC 15: RANKINGS ACCORDING TO YOUR SALES

Evolución posiciones 2015 vs 2016 - Ventas			
Ranking	Posición 2015	Posición 2016	Evolución Posiciones
Nacional	514	460	54 ↑
Castellon	2	1	1 ↑
Sector CNAE 2331	1	1	0 →

Source: commercial data of PamesaCeramica

PamesaCeramicaSl is in the 1st position in the ranking of the ceramic tile manufacturing sector, with a turnover of 336,705,000 €.

Next, you can consult the position in the ranking of PamesaCeramica S L and companies with similar positions:

GRAPHIC 16: RANKING POSITIONS

Posición Sector	Evolución Posiciones	Nombre de la empresa	Facturación (€)	Provincia
1	0 →	**PAMESA CERAMICA SL**	**336.705.000**	**Castellon**
2	0 →	PORCELANOSA SA	175.505.470	Castellon
3	0 →	ARGENTA CERAMICA SL	164.377.599	Castellon
4	0 →	COMPACGLASS SL	132.836.000	Castellon
5	0 →	BALDOCER SA	129.612.919	Castellon
6	1 ↑	KERABEN GRUPO SA	117.984.000	Castellon

Source: commercial data of PamesaCeramica

PamesaCeramicaSl is in position 1 of the Castellon Ranking, with a turnover of 336,705,000 €.

Next, you will be able to consult the position in the ranking of PamesaCeramica S L and companies with similar positions:

GRAPHIC 17: RANKING POSITIONS

Posición Provincia	Evolución Posiciones	Nombre de la empresa	Facturación (€)	Sector Actividad
1	1 ↑	**PAMESA CERAMICA SL**	**336.705.000**	**2331**
2	1 ↓	UBE CORPORATION EUROPE SA	314.281.000	2014
3	0 →	MARTINAVARRO SL.	266.405.758	4631
4	0 →	FERRO SPAIN SA	205.362.000	2349
5	2 ↑	GREENMED SL	191.079.736	0123
6	1 ↓	PORCELANOSA SA	175.505.470	2331

Source: commercial data of PamesaCeramica

PamesaCeramicaSl is in position 460 of the National Ranking of Companies, with a turnover of 336,705,000 €.

Next, you can consult the position in the ranking of PamesaCeramica S L and companies with similar positions:

GRAPHIC 18: RANKING POSITIONS

Posición Nacional	Evolución Posiciones	Nombre de la empresa	Facturación (€)	Sector Actividad	Provincia
455	54 ↓	GARCIA MUNTE ENERGIA SL	337.931.314	4671	Barcelona
456	17 ↓	VESTAS EOLICA SA	337.393.091	3519	Madrid
457	37 ↑	APPLE RETAIL SPAIN SL	337.207.209	4741	Madrid
458	50 ↓	ENCE ENERGIA Y CELULOSA SA.	337.189.000	1711	Madrid
459	56 ↓	LABORATORIOS CINFA SA	336.833.302	2120	Navarra
460	54 ↑	**PAMESA CERAMICA SL**	**336.705.000**	**2331**	**Castellon**
461	11 ↓	COMPAÑIA TRASMEDITERRANEA, SA	335.769.000	5010	Madrid
462	80 ↑	SEMPSA JOYERIA PLATERIA SA	335.130.000	2441	Madrid
463	2 ↓	GRUPO GENERAL CABLE SISTEMAS SL	334.878.000	2732	Barcelona
464	44 ↓	FAGOR EDERLAN S.C.	334.620.000	2932	Gipuzkoa
465	31 ↑	INDUSTRIAS LACTEAS ASTURIANAS SA	334.505.562	1054	Asturias

Source: commercial data of PamesaCeramica

7.2.- LIMITATIONS AND FUTURE RESEARCH

In particular, we can conclude the work with some recommendations that have been achieved thanks to understanding the limitations of the application of this technology and the concept of innovation that is currently being developed in the sector.

As we have seen in the project, the ceramic industry in countries such as Spain develops its activity focusing on the quality and design of its products. In view of this fact, according to the findings of the study, investment in this technology is currently insufficient.

Above all, the only advantage it brings to companies is that they are on a par with the competition in terms of quality and design. But beyond these facts, the industry we have studied is a mature one, and the products have been heavily exploited, due to their traditional use. In addition to that, there are markets that offer the same products with lower quality and lower prices, so they can be some important substitutes for the products of Spanish companies.

For this reason, it is not enough to develop products to maintain the level of competition, companies in the sector must invest in these technologies beforehand and it is not enough to satisfy the current need. But very long-term companies must invest in meeting new customer needs to extend the life of the industry.

It is true that products are currently being developed for other needs, in addition to the basic ones that cover the original product. Projects such as those developed by the company, "KERAjet", aim to cover other needs and implement the markets in which the company operates. But now these projects are not very commercially exploited.

In addition to projects to meet new needs, allowing the company to diversify its business. At the organisational or marketing level, innovations have been on the back burner throughout the life of the sector, so the short-term development of innovations in these areas can enable companies to differentiate themselves from their competitors.

Therefore, we can conclude the project by stating that inkjet technology has been a major advance in the sector, as this sector focuses on the exploitation of its products through differentiation in design and quality.

For this reason, this technology has allowed us to improve the designs, which allows us to offer our customers the best designs, adapting to the demands of the market. While seeking innovation as a source of competitive advantage for companies, companies must go beyond these innovations and seek to meet new customer needs to extend the industry's lifecycle.

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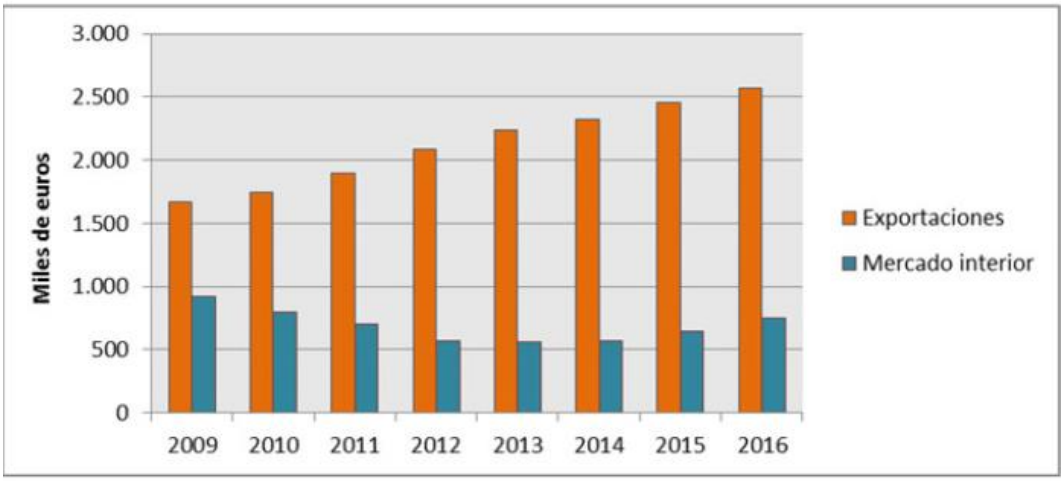
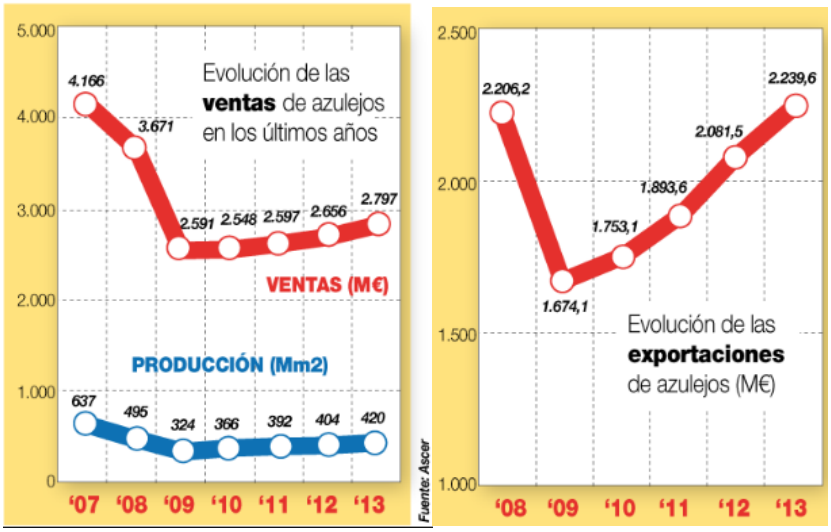
ANNEXED

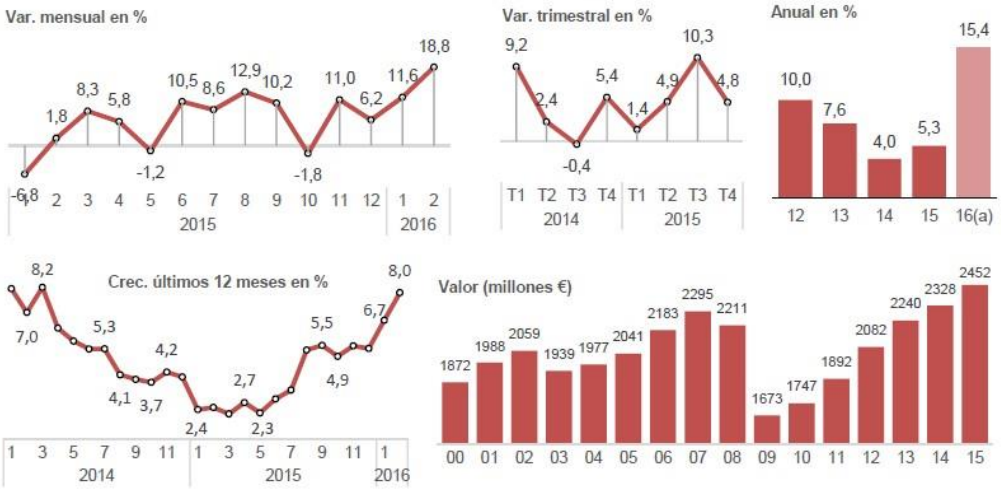
-ANNEXED 1

GRÁFICO 1: Evolución de las ventas de azulejos y pavimentos cerámicos (2009-2016).





Evolución del valor de la exportación



Evolución del precio medio de exportación

-ANNEXED 2

INDEX BY COLLECTIONS

COLECCIÓN COLLECTION COLLECTION	SERIE SERIES SÉRIE	FORMATO SIZE FORMAT	FAMILIA DE PRODUCTO PRODUCT FAMILY FAMILLE DE PRODUITS	PÁGINA PAGE PAGE
AGATHA RUIZ DE LA PRADA	ACATHA	25X25	RVTO. PASTA BLANCA	22
	ACATHA Coeur			
	ACATHA Mille Cuori		COMPACCLASS	
	VIA AGATHA	22.3X22.3	RVTO. PASTA BLANCA	26
	AGATHA	25X50		28
EDEN	VAASA	40x120	RVTO. PASTA BLANCA	34
	VANNES	40x120	RVTO. PASTA BLANCA	36
	VESTAL	40x120	RVTO. PASTA BLANCA	38
	VILLARD	40x120	RVTO. PASTA BLANCA	40
	VOLTERRA	40x120	RVTO. PASTA BLANCA	42
	VOSS	40x120	RVTO. PASTA BLANCA	44
	WHITES	40x120	RVTO. PASTA BLANCA	46
	ADAIR	30X90	RVTO. PASTA BLANCA	48
	AHAR	30X90	RVTO. PASTA BLANCA	50
	ALBION	30X90	RVTO. PASTA BLANCA	52
	ALIX	30X90	RVTO. PASTA BLANCA	54
	ALVORD	30X90	RVTO. PASTA BLANCA	56
	ATKA	30X90	RVTO. PASTA BLANCA	58
	AYDEN	30X90	RVTO. PASTA BLANCA	60
	AYERS-AYR	30X90	RVTO. PASTA BLANCA	62
	ACTON	25X75	RVTO. PASTA BLANCA	64
	AGAR	25X75	RVTO. PASTA BLANCA	66
	ANZA	25X75	RVTO. PASTA BLANCA	68
	ARCADIA	25X75	RVTO. PASTA BLANCA	70
	ARP	25X75	RVTO. PASTA BLANCA	72
	ARTOIS	25X75	RVTO. PASTA BLANCA	72
	SABIN	25X25	RVTO. PASTA BLANCA	74
	SAXON	25X25	RVTO. PASTA BLANCA	76
	COWAN / RLV COWAN	30.3X60.5	RVTO. PASTA BLANCA	78
	CREST / RLV CREST	30.3X60.5	RVTO. PASTA BLANCA	80
	CUNEX	30.3X60.5	RVTO. PASTA BLANCA	82
	CYRUS	30.3X60.5	RVTO. PASTA BLANCA	84
	WHITES	30.3X60.5	RVTO. PASTA BLANCA	86
	SCENIC	15X60.5	RVTO. PASTA BLANCA	88
	SIREN	15X60.5	RVTO. PASTA BLANCA	90
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	BLOC	25X75	RVTO. PASTA BLANCA	96
	DAMIER	25X75	RVTO. PASTA BLANCA	98
	LEAD	25X75	RVTO. PASTA BLANCA	100
	PLACAGE	25X75	RVTO. PASTA BLANCA	102
	REVER	25X75	RVTO. PASTA BLANCA	104
	SOIE	25X75	RVTO. PASTA BLANCA	106
	SOUL	25X75	RVTO. PASTA BLANCA	108
	WABE	25X75	RVTO. PASTA BLANCA	110
	WHITE	25X75	RVTO. PASTA BLANCA	112

ÍNDICE POR COLECCIONES / INDEX BY COLLECTIONS / INDEX PAR COLLECTIONS

COLECCIÓN COLLECTION COLLECTION	SERIE SERIES SÉRIE	FORMATO SIZE FORMAT	FAMILIA DE PRODUCTO PRODUCT FAMILY FAMILLE DE PRODUITS	PÁGINA PAGE PAGE
PVTO. PASTA ROJA PASTA ROJA	ALCORA	31.6X31.6	PVTO. PASTA ROJA	212
	ARCOIRIS	31.6X31.6	PVTO. PASTA ROJA	213
	AVILA	31.6X31.6	PVTO. PASTA ROJA	214
	CASTLE	20X60	PVTO. PASTA ROJA	216
	CORONA	45X45	PVTO. PASTA ROJA	218
	CREA	31.6X31.6	PVTO. PASTA ROJA	219
	DANA	45X45	PVTO. PASTA ROJA	220
	DELFOS	45X45	PVTO. PASTA ROJA	221
	DREAM	45X45 / 31.6X31.6	PVTO. PASTA ROJA	222
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